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EXECUTIVE SUMMARY

January 18, 1985

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REVIEW AND EVALUATION OF BUREAU OF LAND MANAGEMENT RANGELAND REMOTE SENSING

INTRODUCTION

Colorado State University was commissioned on August 14, 1984, by the Bureau of Land Management through the Denver Service Center to conduct a review and evaluation of the Bureau's remote sensing program with special emphasis on rangeland remote sensing. Critical elements underlying this initiative were: (1) the need to develop viable future programs for remote sensing applications as assets to land management planning and (2) the requirement of the Bureau to prepare and keep current information on range condition and trend of public lands with limited resources.

The task was completed by obtaining data and information from eleven western states, the eastern states combined, and the Denver Service Center. The procedures were (1) interviews with Bureau personnel involved in remote sensing at the Denver Service Center, and in Idaho, Arizona and New Mexico State, District, and Resource Area offices and in the Riverside California District Office, and (2) use of questionnaires submitted to all locations requesting information on remote sensing uses. In all cases, key information solicited included: (1) listing of data elements and information items required for a (the) specific objectives(s),(2) kinds of remote sensing used to assist in meeting the objective(s),(3) applicability of the remote sensing results as an asset to the specific objectives(s), and (4) possible uses of a remote sensing system to help meet current and/or potential renewable natural resources objectives.

Following are the findings of the investigation and recommendations for consideration toward implementation of a viable Bureau remote sensing program.

We sincerely appreciate the courtesies extended to us by all Bureau personnel contacted for assistance in accomplishing the task. In all cases, they were candid and professional in responding to inquiries.

FINDINGS

1. A high level of enthusiasm and professionalism was evidenced by Bureau of Land Management personnel in the development and implementation of new and improved techniques which would assist in coping with complex management decisions.

2. Many Bureau managers and specialists expressed serious concern with their capabilities to perform the apparent level of rangeland monitoring required, considering presently available or foreseeable resources. Consequently, they are extremely interested in applying new techniques including remote sensing to assist in accomplishing their requirements.

3. The Public Rangelands Improvement Act (PRIA) requires that the Bureau prepare information on range condition and trend. This requirement, and the need to develop and complete environmental statements has increased emphasis on rangeland monitoring, with an apparent decrease in activities for rangeland inventory. The decentralized nature of the Bureau has allowed field units to independently define their information needs and develop their their own procedures to meet that PRIA and other requirements for monitoring. This has resulted in a general discontinuity of information requirements among field units and development of procedures to obtain required information. However, frequency of

individual plant species within plant communities alone or in combination with other species attributes within the community is the most common attribute.

4. Current literature on rangeland remote sensing indicates that some identified information requirements are observable and measurable by remote sensing and some requirements cannot be obtained using remote sensing. Also, current literature indicates that inferred "off-the-shelf" technology has been insufficiently documented for immediate application; some applications procedures need to be prepared.

5. There is a general lack of adequate training and awareness of remote sensing techniques and applications at all management and specialist levels.

6. There is a lack of clear direction within the Bureau on goals and objectives to recognize opportunities for using remote sensing for range management activities. This finding is related to Finding 3 and the lack of a minimum set of data elements and information requirements for renewable resource monitoring and inventory.

7. Generally, there was a lack of detailed project planning prior to initiation of Landsat and other remote sensing application demonstrations. Consequently, unsatisfactory communication, understanding, and agreement on project goals, objectives and expected products developed.

8. The apparently acceptable Level II land cover classifications attainable from analysis of Landsat multispectral data were generally not of sufficient detail to satisfy Bureau rangeland monitoring and management requirements. Level IV land cover classification is the minimum necessary for detailed project planning. Level III may have some applicability for generalized project planning.

9. Accuracy assessments of Landsat products were generally not accomplished in favor of increasing project area coverage.

10. There is an assumption among many Bureau personnel that, since Landsat data are in digital form, its use for vegetation (land cover) classification results is an optimum vegetation classification for incorporation into a geographic information system. This assumption was made apparently regardless of level of accuracy and/or level of classification.

11. The Denver Service Center image processing computer system requires upgrading and significant maintenance to continue internal Landsat or other digital remote sensing data processing capabilities by the Center.

12. There has been little effort by the Denver Service Center to evaluate or assist in implementation of promising aerial photograph techniques for range management monitoring or inventory. Part of the reason for this has been emphasis on evaluation of Landsat imagery for range management and other purposes. Con-

sequently, some field offices have done these evaluations independently and with little coordination with the Denver Service Center or other field units.

13. There is a lack of adequate field office photointerpretation equipment and material.

14. The Denver Service Center has maintained excellent rapport with several centers of remote sensing expertise. The Center should continue and expand this activity.

15. Procedures for storage and retrieval of aerial photographs and other supporting data about renewable resources monitoring and inventory is lacking.

RECOMMENDATIONS

Establish Remote Sensing Program

Resource managers at all levels in the Bureau of Land Management are, in general, aware that available resources for the foreseeable future are likely to be inadequate to accomplish essential resource monitoring activities by conventional ground methods. A considerable basis already exists for consideration of remote sensing as a cost-effective monitoring supplement coupled with ground data range resource assessment. For example, tree and shrub species can be acceptably identified with appropriate large scale color infrared aerial photographs and, with sampling, can provide estimates of cover, density, and perhaps frequency. The high degree of professionalism, enthusiasm, and recent remote sensing experience at State, District and Resource Area offices presents an excellent opportunity to carefully test and evaluate promising remote sensing techniques, especially those using aerial photographs, for renewable resource assessment and monitoring.

Recommendation Number 1. The Bureau of Land Management, through the Denver Service Center Remote Sensing Staff, should fully commit to a remote sensing program, with emphasis on aerial photographic techniques for rangeland and other resources assessment and monitoring. The program should consist of the following basic elements.

- Maintain a state-of-the-art familiarity with current developments in remote sensing techniques and application.
- Maintain suitable internal capabilities to evaluate and assist in implementing at field offices appropriate remote sensing technology.
- Continue to seek, establish and maintain cooperative working relationships with centers of remote sensing expertise.
- Support and supervise external applications studies designed to bring useful new remote sensing technology into range management and other resource systems.

Develop Aerial Photography Applications Program

The use of aerial photographs for Bureau range resource inventory and monitoring has been de-emphasized during the last 6 to 8 years in order to make evaluations of Landsat data for those purposes. Nevertheless, developmental work with large and small-format aerial photography applications have occurred, mostly at field offices. Types of applications accomplished, but not fully documented, or in progress and which are related to both inventory and monitoring include reparian habitat evaluation, range vegetation trend analysis, wildlife habitat classification, and watershed management (e.g. water quality, soil erosion, stream quality for fisheries, and plant cover effects and changes on fisheries and wildlife.

Recommendation Number 2. Develop a vigorous aerial photography applications program which includes:

- The Denver Service Center should continue to assist the Bureau state organizations, when requested, in the specification, acquisition and application of medium scale (1:12,000 - 1:36,000) large format resource photography.

- Intensive evaluation of NHAP (National High Altitude Aerial Photography Program) photography capabilities for Bureau resource management applications is needed. Also, the Bureau should continue supporting the Program because of its sequential nature (reflights at 4-5 year intervals), low unit cost and high photographic resolution. Closer involvement by the Bureau in future NHAP program planning should occur and could result in more effective timing and selection of location of overflights to be more responsive to Bureau resource management needs.

- Evaluate the capabilities of large scale (1:500 - 1:3,000 and up to 1:10,000) large and small format aerial photography to supplement existing range monitoring systems. Develop procedures and methodology for field use.

- Fully document, by widely distributed formal reports, results of all testing and evaluation projects.

Provide Remote Sensing Training

Despite the proven importance of remote sensing as a practical cost effective resource management and monitoring tool, many colleges and universities no longer provide adequate practical remote sensing training. As a consequence, most major resource management agencies, including the Bureau, have been forced to develop and carry out their own training programs. This situation is not likely to improve. As a matter of fact, it appears to be worsening with the result that the responsibility of providing remote sensing training will increasingly be the responsibility of the management agencies.

Currently, many key natural resources staff personnel, unit managers, resource managers, professionals, and technicians have an inadequate comprehension of remote sensing. A minimum level of remote sensing understanding including use of aerial photography and digital imagery is required to improve internal capability to apply remote sensing techniques to renewable resource management actions and recognize the limitations of remote sensing for some applications.

Recommendation Number 3. The Bureau, through the Denver Service Center, should maintain and enhance remote sensing training programs by providing:

- Basic training in aerial photo interpretation and photogrammetry.
- Basic training in the understanding and proper application of the different kinds of remote sensing (e.g. aerial photography, multi-

spectral sensing, radar and radiometers).

- When required, provide training in appropriate remote sensing techniques for discipline-oriented applications (e.g. range, wildlife, hydrology, forestry) in which field resource specialists become aware of and have the opportunity to apply specific techniques for specific purposes.
- Provide guidance in the selection of appropriate field level remote sensing analysis equipment and materials.
- Provide awareness training for managers responsible for resource management programs.

Digital Remote Sensing Data Analysis

Capabilities and limitations of conventional Landsat multispectral scanner data (4-band, 80-meter resolution) have been adequately defined. Generally, land cover classification is accomplished, at a maximum, to Level II (e.g., Deciduous Forest, Shortgrass Grassland, Evergreen Shrubland). Such information is of minimum value for Bureau rangeland management applications. Information of potentially greater value is available from other sources such as aerial photography and archived data files. However, the application values of the Landsat Thematic Mapper data (7-band, 30-meter resolution) have yet to be defined. Higher resolution data from future satellite remote sensing systems can be expected and will require evaluation.

Recommendation Number 4. The Bureau, through the Denver Service Center, should maintain a minimal but viable internal capability for satellite digital remote sensing data analysis.

- Conventional Landsat image analyses capabilities should be maintained at a level sufficient to meet limited, but important, user requirements (e.g., agricultural infringement in rangelands, wildfire mapping, dramatic land surface disturbances such as mining).
- Internal evaluation capabilities of current and future satellite remote sensing digital data which have high probability of practical utility for rangeland management activities should be maintained.

Remote Sensing - Geographic Information Systems

The Bureau is working aggressively toward development and implementation of Geographic Information System (GIS) technology at the field offices. A critical data theme for a GIS is an accurate current vegetation map suited to management needs. Digital analysis of conventional Landsat data generally provides inadequate detail for range management project use. Nevertheless, the fact that Landsat is in digital form has led to the misconception that it is automatically the optimum vegetation data source for direct inclusion into a GIS.

Recommendation Number 5. The Bureau, through the Denver Service Center, should make a critical review and evaluation of the relationships between remote sensing digital image processing and products and data entry into a GIS. The Service Center should evaluate all potential sources of remotely sensed vegetation information for inclusion into a GIS. Source selection should be based upon data resolution requirements, accuracy, needs, and cost.

Remote Sensing Coordination

Establishment of an active and effective remote sensing program within the Bureau requires the continued interest, support, and direct involvement of Bureau Washington Office, State, District and Resource Area personnel. A key component of this program exists in the form of designated Remote Sensing Coordinators at State and, in some cases, District and Area offices. Currently, the remote sensing coordinator function is usually combined with other responsibilities such as Geographic Information Systems development and coordination.

Recommendation Number 6. The Bureau should continue active support of the Remote Sensing Coordinator Concept.

- Personnel assigned as Remote Sensing Coordinators must be technically qualified and highly motivated in applications of remote sensing and have an understanding of renewable natural resources. While initially a position combining remote sensing and other responsibilities appears logical, each of these functions could develop into full-time responsibilities, often with separate and distinct technical capability requirements.

- A Remote Sensing Resource Advisory Team comprised of the State, Denver Service Center, and Washington Office Remote Sensing Coordinators, and including resource specialists, should be established. The Team should be chaired by the Chief, Branch of Remote Sensing, Denver Service Center.

The responsibilities of the Team should include:

- Assistance in development and prioritization of Bureau and Denver Service Center remote sensing programs.
- Upon request, review internal and external remote sensing proposals to assure technical competency, avoid duplication and assure compliance with user requirements.
- Upon request, review Bureau remote sensing projects. Establish, initiate and maintain a remote sensing technology transfer program.

Information Needs and Large Scale Photography

The Bureau has not established a minimum set of data and information requirements and standards for monitoring and inventorying renewable natural resources. This has led to a general discontinuity of information requirements since each field unit has independently defined data and information requirements. This has resulted in a proliferation of data and data collection procedures which may or may not be compatible. Also, there are no easily adaptable range remote sensing techniques that can be immediately implemented without preparing and documenting applications procedures. This is because of the relationship of remote sensing research and development to geographic locations and technology transfer; a proven technique for one location needs to be verified at other locations. As a result of initiatives at field offices, several opportunities exist, for example in California, Oregon, Idaho, and Arizona, to evaluate the application of remote sensing data for monitoring. At these locations, recent (4-6 years) large scale aerial photography and supporting ground data exist. Evaluation and documentation of the applicability of the remote sensing technique used to obtain specific kinds of data to supplement range monitoring procedures needs to be conducted.

Recommendation Number 7. The Bureau, through the Denver Service Center and with the Branch of Remote Sensing and the Division of Resources Systems collaborating, should define a minimum set of data elements and information requirements to assure compatibility of data collection and data aggregation. Also, these Units should collaborate in testing and evaluating large and small format aerial photography to supplement range monitoring systems. Appropriate remote sensing and resource field specialists should provide as much assistance as possible. Procedures and applications for field operations should be developed. The need to secure contractual assistance should be considered during development of the evaluation plan, data analysis, and preparation of technical procedures and instructions. Conclusion of this work, within three years, will provide an additional basis for future Bureau remote sensing programs in support of rangeland and other renewable resource management programs.

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